

XIII. *Observations on Sand Iron: In a Letter from Mr. Henry Horne, to Mr. John Ellicot, F. R. S.*

S I R,

Read March 3,
1763.

AS the affair of the rich American Iron Ore, commonly known by the name of the Virginia black sand, has of late not only engaged the conversation of many of the Virtuosi, but has been taken very particular notice of by the Society for the encouragement of arts and manufactures; I thought myself obliged, for many reasons, to lay before you whatever has come to my knowledge relating to this discovery, either from my own experiments, or from the information of others. And I engage in this service with the greater pleasure, as I look upon it to be one of the most interesting discoveries, with regard to this useful metal, that has come to our knowledge for some ages, and, if rightly conducted, may prove of infinite service to us in this part of the world, as well as to the inhabitants of our colonies, where (as it has been supposed, though without sufficient foundation) this discovery was first made.

Without any farther preface or apology, permit me to remind you, that, in a conversation which formerly passed between us upon this subject, I acquainted you, that, about twenty years since, I was engaged in making a variety of experiments upon the nature of Iron Ores, and Steel; and that I then made a very

very particular enquiry into the nature of this black sand, and, in the course of these experiments, several very interesting phenomena discovered themselves, which, as they might be of great service to the world in general, and more especially to such as are concerned in smelting of the iron from the ore, I had thoughts of communicating to the publick; but, as my business will not permit me to go through the whole at present, I shall confine myself to what relates to the black sand.

I procured, from Mr. Adams the Virginia merchant, a sufficient quantity of the sand, and, in order to estimate its comparative weight with that of iron ore, I procured some of the richest ore I could get, which having reduced to powder, I filled an ordinary tea-cup with it. I afterwards filled the same cup with some of the sand, and upon comparing the weights with each other, I found that the weight of the sand was to that of the ore as 3 to 2; and having taken notice how readily the sand was attracted by the magnet, I was convinced that the sand must certainly contain a very considerable quantity of Iron, and therefore determined to make trial of it. I was however, for some time, interrupted in my design, by information I received from a friend, that such an enquiry had been made many years before, by a member of the Royal Society, and a gentleman of esteem as a chemist, but without success; and that the experiments were published in the 2d vol. of Lowthorp's Abridgment of the Philosophical Transactions. As this account is very short as well as curious, I shall take the liberty to give it you entire, with some few remarks upon it.

" A black shining sand from Virginia examined by Dr. All. Moulen.

A small vial filled with ordinary white sand, and containing only 3 i. gr. xi. being filled with the Virginia sand, was found to contain 3ij, 3ij. gr. i.

This sand did apply to the magnet both before and after calcination ; but the latter did apply better to it than the former.

A parcel of this sand, mixed and calcined with powdered charcoal, and kept in a melting furnace for about an hour, yielded no regulus: but applied more vigorously to the Loadstone than either of the former.

I fluxed a parcel of this sand with fixed nitre, in a melting furnace, for above an hour, but could obtain no regulus ; nor any substance that would apply to the magnet, except a thin crust that stuck firmly to a piece of charcoal that dropt into the crucible when the matter was in fusion.

I fluxed it also with salt-petre and powdered charcoal, dropping pieces of charcoal afterwards into the crucible. It continued about half an hour in the melting furnace in fusion, and that without producing a regulus, or a substance that would apply to the magnet, excepting only what stuck to the charcoal as in the former experiment.

I fluxed another parcel of it with salt-petre and flower of brimstone, without being able to procure any regulus.

I poured good spirit of salt on a parcel of this sand, but could observe no luctation thereby produced.

I poured spirit of nitre, both strong and weakened
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with water, on parcels of the same sand, without being able to discover any conflict.

I poured single aqua fortis upon another parcel of it, without being able to perceive any ebullition worth noting.

I used also double aqua fortis upon another parcel of it, which, for ought I could discover, had no more effect on it than the former.

I poured some aqua regia on a parcel of it, without discovering any sensible effect. I poured good oil of vitriol upon another parcel of this sand; but seeing no bubbles thereby produced, I weakened the oil with water, but without any visible effect.

I repeated all the former experiments with the menstrooms upon this sand after calcination per se in a crucible, but could scarce observe a bubble produced by any of them.

I poured some of each of the liquors upon parcels of the powder of this sand calcined, without any success.

Note, that I made these experiments both in the cold, and upon a sand furnace. So that to me there seems to be but little wanting to discover any metal known to us, if it contained any such: for there is no metal nor ore that some of these menstrooms will not work on.

I powdered a fragment of a loadstone, and poured some of these menstrooms upon it, without being able to find that they in the least preyed upon it, any more than they did upon the sand.

I poured some of the aforementioned menstrooms upon ordinary sand taken out of a sand furnace, where it must have suffered some calcination; but could

find no more bubbles produced thereby, than what might rationally be supposed to be produced from lime, and other dirt mixed with the sand."

Having thoroughly considered these experiments, they appeared to me far from being decisive, and that if the Doctor had placed more confidence in the power of the magnet, and less in his menstrooms, he would rather have concluded that there might be some sorts of iron ore which his menstrooms would not touch in the moist way, nor any regulus be produced from them in the dry, as he made use of them, which yet might, under some other hands, be subdued, by more apt and powerful methods than any which at that time he was acquainted with.

However I apprehended I might fairly draw this conclusion from his experiments, viz. that the sand was not altogether and simply iron, but that it was strongly united with a very stubborn, fixed, and permanent earth, which could not be separated from it without some extraordinary, as well as powerful means; but I could not think this a sufficient objection to the prosecution of an experiment, which, if it succeeded, might be attended with very happy consequences. Proceeding therefore upon this supposition, I mixt up about 8 or 9 ounces of the sand, with a proportional quantity of a strong corrosive flux, which I put together into a crucible, and committed it to a very strong fire in an excellent wind-furnace, where I kept it for between two and three hours, hoping by this means to have answered the intended purpose; but I confess I was not a little surpris'd, that, after the crucible was taken from the fire, I could not
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find one single grain of metal in the remaining contents.

This disappointment greatly puzzled me, till having thoroughly examined into the unexpected event, without being able to discover any reason sufficient to incline me to recede from my former opinion, as to the component parts of the sand, I concluded that the flux might possibly be a very improper one; for though it might have effected the intended separation, yet it might at the same time be sufficiently powerful to divide the particles of the metal, when separated, so very minutely, as to be capable of subliming and carrying them off imperceptibly: And finding the contents greatly diminished, so that the quantity remaining bore but a small proportion to that which was first put into the crucible, I concluded that this must really have been the case, and that some very different method must be pursued in order to produce the desired effects. I immediately determined to make a second trial, in which I proceeded in the following manner. I took the same quantity of sand made use of in the former experiment; and first I spread it, without any addition to it, upon an iron plate over a strong fire, where I gave it a very powerful torrifaction (or roasting) to try if, by that means, I could not relax, and loosen the component parts to such a degree, as to make the separation and reduction of the metal more easy, when I should bring it into the furnace. When I had so done, I mixed it up with a flux of a very peculiar, but gentle nature, which I had before made use of for other purposes with great success, and committed it (as in the former experiment) to the furnace, where I urged it by a very strong fire for about

three hours, and upon taking it out, I found the event answerable to my most sanguine expectations: for in the bottom of the crucible I found, as near as I can remember, rather more than half of the sand I put into the crucible reduced to a very fine malleable metal.

In this very agreeable experiment I met with a very surprizing phenomenon, which, as I am not at present able to determine whether it was only casual, or what would always happen in the like experiments, you will excuse my divulging at present, especially as you, Sir, by furnishing me with a fresh parcel of the sand, have enabled me to make some farther trials; which I shall embrace the first opportunity of doing; and should I be so happy as to confirm what I then observed, or to make any farther discoveries deserving your notice, I shall not fail communicating them to you.

Being fully convinced, by the experiment, that the sand was a very rich iron ore, I acquainted some of my friends with it, who being largely engaged in trade to those parts of our American colonies, where I was informed this sand was to be easily procured, and in very large quantities, I was in great hopes an account of this nature would have inclined some of the gentlemen in that part of the world, to have prosecuted so useful a discovery in a larger way; and I own I have often wondered, that an affair of such consequence should have lain dormant for so many years.

However I was a few months since pleasingly surprised, to find in the hands of my very ingenious friend Mr. Peter Collinson, not only a pamphlet, but
likewise

likewise a letter upon the subject addressed to the Society for encouraging of arts and manufactures, by one Mr. G. Elliott, who relates, that, though previous to his attempt of making iron from this sand, he met with nothing but what was discouraging from the most skillful persons to whom he proposed his design, yet that he had such a persuasion in his own mind of the practicability of the thing, that he could not rest till he had made a trial, and the event proved encouraging much beyond his expectations, insomuch that he could scarcely believe the trial had been fairly made, till a second trial evinced with certainty, that eighty three pounds of the sand would produce a barr of excellent iron weighing fifty pounds: a prodigious yield indeed, and far beyond what I have ever heard of from the richest common ores that are any where to be found; most of the ores I have ever met with or heard of, yield little more than half in pig metal, and which will suffer a waste of near $\frac{1}{2}$ part to make tolerable good barr iron, and much more if I am rightly informed, when the iron is intended for more valuable purposes, such as being drawn into wire, &c.

After I had seen his address in his letter to the Society, and his pamphlet; by the assistance of my friend Mr. Collinson, I sent him over two or three hints, which I judged might be of some service to him; this produced the favour of a letter from him, of which the following is an exact copy.

Mr.

Mr. HENRY HORN,

Sir,

Killingworth, Oct. 4. 1762.

I Understand by Mr. Collinson, that you have seen, and greatly approve of, the sample of sand iron which was sent; that you are desirous to know how it was made, and whether it can be made in large barrs. The little barr you saw, was cut off from a barr of 52 pounds and a half, the first that was made at my son's work, the first that was ever made in America, and probably the first that was ever made in the world, in that manner, and so large a barr. I never heard of any attempt made upon the iron sand, till that of yours 20 years ago, of which Mr. Collinson gave me an account in his letter.

As to the manner of making the iron, it is wrought or smelted in a common bloomary, in the same manner as other iron ore is smelted; excepting this difference, this iron sand is so pure, so clean washed, that there is not a sufficient quantity of cinder or slagg to promote and perform the smelting, therefore we add either the slagg which issues from other iron, or else add some bog mine ore, which abounds with cinder; in this way it is as capable of being wrought as rock ore or bog mine.

I was in hopes that if this iron sand could be wrought at all, the particles being so very fine, it would smelt very quick; but herein I found myself mistaken, every particle has a will of its own, and must have its own particular smelting, for instead of its being performed in less time, it took more than
common

common iron ore, but, upon farther experience, and more acquaintance with this sand, the workman has shortened the operation from five hours down to three: if by any means it might be reduced to the same time with pig iron, it would be a most useful improvement. If you can afford any directions to hasten the operation, I should be greatly obliged for any instructions.

There is so much of this sand in America, that I am apt to think, that there is more iron ore in this form of sand than in mines.

I have written an essay upon the subject, which I hope Mr. Collinson will let you see, as I hope to see what you are about to publish. My son has a steel furnace, which was erected several years before the act of parliament prohibiting them in the plantations: he has converted some of the sand iron into steel, of which I send you a sample; as also a sample of the iron. As my son had no instructions for making steel, we were forced to hammer out the skill by various trials as we could; so conclude that he is still imperfect, and wants your help and direction to bring it to perfection, in which art I understand that you are a perfect master, and withall kind enough to offer your assistance; for which I am very thankful, and look upon it as an additional favour, if you will be pleased to indulge me with the benefit of your correspondence, for I live in a corner of the world where such information as, I trust, you are able to furnish, will be highly beneficial. Previous to my attempt of making iron from sand, I proposed my project to those who were the most skillful in those affairs, but met with nothing but what was discouraging; yet after all,

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had a persuasion of the practicability of the thing to a degree next to enthusiasm, so that I could not rest till I had made trial. I am glad that the iron has such qualities as to meet with your approbation; I knew that the iron was good, but did not know that it was so good as your superior knowledge has found it. I want to know what such iron will sell for in England, whether it will be worth while to send it. This black sand is a treasure that has long lain hidden from the world, and is what may render the colonies more valuable to Great Britain.

I am, Sir,

Your most obliged humble servant,

Jared Eliot.

P. S. The bars of iron which have hitherto been made of sand, are from fifty to fifty gross, hope in time to have them reach to seventy pounds weight each; experience must determine that matter, we can do better than at the time the essay was written. We have been visited with a long and sore drought, have done nothing for a long time for want of water.

The samples which accompanied this letter, were two small bars, weighing only a few ounces, one of the iron made from the sand, the other of steel made from the same iron. These bars I have tried, and found that the bar of steel worked extremely well under the hammer, was very pure and clean, and free

free from flaws. On the contrary the barr of iron turned out much otherwise, for, though it appeared to bear the force of the hammer, as well as the steel, yet it was not near so pure, but broke out in flaws and hollows, almost through the whole of the barr, and which a welding heat would by no means bring into proper union; this however engaged us to try a different method, which was, when the barr was reduced into a proper size for the purpose, to double it up three times, one part of the barr upon the other, and to try if it would then bear welding and become more consistent, and by this means we found the end perfectly well answered; for it bore the force of the fire and the hammer, and became in a manner perfectly sound. This severe trial proved, to a demonstration, that the iron possess all that agreeable toughness and ductility, for which the Spanish iron is so deservedly famous, without partaking of that vile redshire quality, for which the latter is very remarkable, and manifestly tends to prove the excellency of this sand iron, when reduced into barr iron under proper care and circumspection.

You will observe, Sir, from the letter, that this sand is so pure, and so clean washed, that their first method of reducing the sand to barr iron proved too tedious, for want of some of those adventitious materials, to promote and perform the smelting, and which always accompanies the common ore, whether it be of the rock or bog kind; which materials, mixing with the matter, made use of by way of flux, and uniting with the ashes of the fuel employed in melting down the ore, is usually run into a thick opake glassy

glassy substance, forming, as it were, a covering over the metal, which, by its gravity, naturally sinks to the bottom; this the workmen call cinder. Now the want of this matter rendering the operation too tedious, I find they had recourse either to this cinder brought from other iron works, or to a quantity of the bogmine, which, I doubt not, would abundantly furnish matter for cinder. If they had used only the first, and that properly chosen, it might very probably have been of some service, without doing any material injury to the metal; but if the bog mine is used, though the service might be apparently more, yet in all likelihood the injury would be infinitely great, and I am inclined to believe that something of this kind occasioned the difference observed between the two bars above mentiond, viz. that the one might have been reduced by the help of more pure materials, and the other by the assistance of their bogmine, whose constituent parts abounding with many impurities, some of which, by mixing with the metal, may have occasioned the defects above complained of, and which required so severe an operation both of the fire and hammer to separate from it. I am therefore of opinion, that as the prosecution of this useful discovery deserves the greatest encouragement, if the Society of arts and manufactures should take it under their patronage, the premium they may think proper to propose should rather be given to the person who shall produce the purest metal, than to him who shall produce the greatest quantity, for otherwise, I am afraid, we shall be deprived of what I should esteem the most valuable part of this discovery, I mean the obtaining

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obtaining a more pure, and better kind of iron, than any we have hitherto been possesst of, and which I am certain this sand, under proper management, is capable of producing.

I am,

Sir, with the greatest respect,

Your most obedient

Feb. 5, 1763.

humble servant,

Henry Horne.